Department of Defense
Report to Congress on
Energy Security Initiatives

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Table of Contents

Department of Defense Report
Energy Security Initiatives

REPORTING REQUIREMENT

The House Report to accompany H.R. 3222, the Department of Defense Appropriations Bill, 2008, H.R. Rep. No. 110-279, page 128, requests the Defense Energy Security Task Force (ESTF) to submit a semi-annual report to the congressional defense committees on the initiatives and activities that the Department (DoD) is taking to promote energy savings and energy efficiency across the Department.

RECOGNITION OF ENERGY AS A LIMITING FACTOR

Energy is a strategic resource that has significant security, economic, geo-strategic and environmental implications for the nation and important operational implications for the Department. For example, in FYs 2006 and 2007, DoD's total energy costs exceeded $13 billion, and an additional $5 billion was requested in FY 2008 obligational authority to ensure we can support the increased fuel costs. Like the nation, DoD must focus on reducing demand through culture change and increased efficiency. The intensity of day-to-day fuel demand in Iraq and Afghanistan is greater than in any war in history. This has required ever greater numbers of large logistics convoys along vulnerable lines of communication that are prime targets for insurgent forces. Protecting these convoys imposes a high burden on our combat forces, by diverting combat units from direct engagement to force protection missions. This will continue to be a burden in any scenario in which we face an asymmetric threat. The strategic importance of energy security is well appreciated by decision-makers. However, Operations Iraqi Freedom and Enduring Freedom have reminded us that energy is tactically relevant, and field commanders are looking to the Department and Services to provide battlefield solutions that reduce vulnerability while increasing capability.

Fig. 1. Fuel convoys in Iraq

In 2001, a Defense Science Board (DSB) task force estimated the minimum cost of delivering over-land fuel in a combat zone to be $15 per gallon without including force protection, and the cost of delivering a gallon of fuel through an airborne tanker at $26 (excluding the cost of buying the aircraft). These estimates were based on a

commodity price at the time of less than ninety cents per gallon for fuel. In 2006, the JASONS[1] estimated the cost of delivering a gallon of fuel via an airborne tanker, including a small proportion of the cost of the aircraft, at approximately $42 per gallon. The term coined to capture this more realistic cost of delivered fuel in theater is "fully burdened cost of fuel," or FBCF. The FBCF (vice fuel-only costs) will be used as part of the cost analysis conducted for new acquisition programs, as well as in retrofit, reconstitution, or upgrades that are being considered. Efforts are currently underway to more accurately quantify FBCF for various types of systems in a range of appropriate scenarios. This will support both smarter force planning and technology development investment.

From a tactical or operational perspective, reducing fuel demand can remove convoys from the battlespace, reduce operational vulnerability, and free combat forces for other missions. More efficient combat and combat-related systems inherently have greater endurance, extending the battlespace by enabling our forces to travel longer distances and remain concealed longer without refueling. From the Departmental force planning perspective, greater energy efficiency in the force provides the option of either reducing the size of the fuel logistics force structure (move people and investment from the "tail" to the "tooth"), or maintaining more reserve logistics capacity to reduce certain future operational risks. Finally, greater fuel efficiency in the force reduces direct operating costs, mitigating the budget effects caused by commodity price volatility.

In May 2006, the Secretary of Defense commissioned the Director, Defense Research and Engineering to chair the Energy Security Task Force (ESTF) to define an actionable investment roadmap for lowering DoD's fossil fuel requirements and developing alternate fuels for use by the Department. The ESTF is comprised of senior leaders from across the Department with a stake in energy, including: requirements development, technology, acquisition, logistics, installations and environment, policy, and the budget. By taking a systems approach, integrating different functional areas, we can better understand the indirect and potentially negative unintended consequences of various courses of action, thereby improving decision making for the Department.

Underscoring the importance of energy to the Department, the Secretary of Defense designated Energy Initiatives as one of the Department's Top 25 Transformational Priorities, and the Military Departments have established energy leads and task forces, responsible for overseeing all energy efforts. The Department is currently working to better understand the value of energy in terms of cost and operational capability, and to modify business processes to more accurately integrate those values into decisions that affect requirements planning, acquisition and funding priorities.

[1] The JASONs is an independent advisory body of highly accomplished scientists and other scholars who self-select endemic issues and challenges facing the Department and attempt to provide actionable solutions.

ENERGY SECURITY INITIATIVES AND ACCOMPLISHMENTS

The Department is actively focused on initiatives to reduce energy demand, increase alternative sources of energy and ensure the energy gets to where it is needed reliably and efficiently. This focus represents a significant strategic shift in priorities, and while efforts are moving forward, this is still a work in progress. Although the Department's emphasis is on addressing energy security, many of these initiatives may also benefit the environment through increased production of renewable energy, improved use of resources and disposal of waste products, and reduced greenhouse gas emissions.

Energy is essential to military operations. Without it, we have virtually no capability. As noted by Deputy Secretary England at the Defense Advanced Research Project Agency's (DARPA) 50th Anniversary event "we will always field the finest fighting force in the world … but that force is extraordinarily energy dependent … and unfortunately, we may be learning the wrong lessons in the Middle East where fuel is readily available. We need alternative solutions."

Important missions and programs are at risk today from interruption of energy supplies and increasing cost. To provide a coherent direction across the spectrum of energy issues, the ESTF is finalizing a DoD-wide Energy Security Strategic Plan to address the issues and focus the myriad of energy organizations that control and are impacted by energy variables. The Plan incorporated insights from recent studies on energy, including the 2006 JASONS' energy study, the 2001 and 2008 DSB energy studies and the 2007 Logistics Management Institute (LMI) study – "Transforming the Way DoD Looks at Energy." The Plan will establish actionable policies, practices and metrics, and will require accountability to secure enterprise-wide buy-in. The Department briefed the plan to the Deputy Secretary's Advisory Working Group (DAWG) in August 2008.

The Services have each established organizational processes for integrating energy efforts and issues. The Army recently named the Deputy Assistant Secretary of the Army for Privatization and Partnerships as their energy executive and has created an Army Energy Security Task Force to address cross-functional issues. The Navy is setting up a Navy Energy Task Force to provide a comprehensive Navy energy governance structure, and for several years, the Air Force has had a well-defined structure, led by the Assistant Secretary of the Air Force for Installations, Environment, and Logistics with several technical panels underneath.

DoD Energy Security Strategic Plan

The ESTF assessed energy consumption of platforms and facilities, identified the largest energy users, and developed an overarching strategy that addresses six functional areas, taking into account supply, demand and distribution considerations:

- Fuel Optimization for Mobility Platforms
- Operational Efficiencies/Optimization and Commercial Practices
- Facility Energy Initiatives
- Domestic Energy Supply and Distribution

- Tactical Power Systems and Generators
- Geopolitical Considerations

As endorsed at the Deputy Secretary of Defense Advisory Working Group on September 3, 2008, the Energy Security Strategic Plan lays out four higher level goals that cut across these functional areas and describe a desired future state for the Department with respect to energy. They are:

1. Maintain or enhance operational effectiveness by reducing total force energy demands ➔ REDUCE DEMAND.
2. Increase energy security through strategic resilience ➔ASSURE SUPPLY.
3. Enhance operational and business effectiveness by institutionalizing energy solutions in DoD planning and business processes.
4. Establish and monitor Department-wide energy metrics.

IMPROVE PROCESSES

In order to enhance mission effectiveness, we must reduce the systemic demand for fuel from DoD platforms, weapons, and fixed and tactical installations. Additionally, the Department must minimize risk in energy – both fuel and electricity – availability, accessibility and distribution to military operations while sustaining operational capability. In addition to improving combat unit capability (by reducing dependence on its fuel tail), some technical solutions for reducing platform fuel demand show promise for increasing individual capability as well. These variables must be considered properly, when weighing the full range of investment choices.

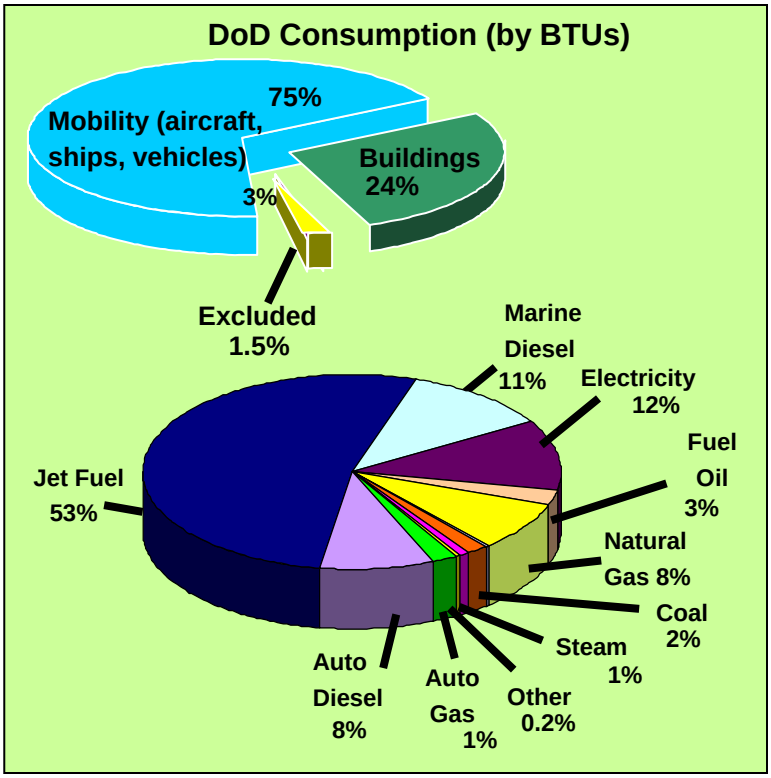

Fig. 2. DoD FY07 Energy Consumption

The Defense Science Board invoked the concept of "resilience", meaning an ability to resist failure and rapidly recover from breakdowns if they occur. Internally, we have expanded this concept to encompass increasing our energy security by shifting reliance toward alternative and renewable sources of energy, reducing dependence on non-assured sources of oil and stabilizing – or reducing – our operational energy demand.

Improving operational effectiveness in the long-term can only be achieved by institutionalizing energy considerations in planning and business processes. Energy security must be addressed explicitly in planning processes throughout the Department. For example in strategic planning, energy considerations were included in the 2005 National Defense Strategy and in DoD internal planning and programming guidance. Strategy and strategic guidance inform force planning and use, which inform material requirements, which, in turn, inform acquisition, modernization and technology development. Properly valuing energy in acquisition decisions will aid in reducing life-cycle operation and sustainment costs, thereby dampening price fluctuation impacts on the Department. We are also identifying opportunities to leverage efforts by other organizations, like federal agencies, industry, academia, and the international community. In addition, the Department is evaluating the strategic and operational implications of global energy economics and associated security issues, including where a global energy supplier has the ability to exert influence over its consumers. The Department also wants to retain its role as a good environmental steward, remaining cognizant of potential environmental impacts and how our actions may be perceived in the globally.

The final goal focuses on measuring our progress by establishing performance targets and metrics based on quantifiable analysis. These performance measures will help to increase awareness and visibility of energy issues; incentivize, measure and reward progress; and change the Department's culture to value energy appropriately. Collectively, these goals establish the framework for managing energy across the Department.

GOAL 1: Reduce Demand

The Department is exploring and implementing technologies that would reduce energy consumption for fixed and tactical installations, platforms and systems. The Installations Community has made significant progress in reducing energy consumption (over 30 percent since 1985). In FY 2007, the Department reduced energy usage by over 10 percent from the 2003 baseline and has a mandate to continue reducing consumption by three percent per year through 2015. This will be accomplished through a variety of technologies such as sustainable design, which will reduce life cycle costs. For platforms, we are combining efforts in a variety of technical areas, including lightweight materials and armor, novel structural shapes and more efficient powerplants (engines, motors, power storage, etc.), to identify ways to reduce fuel consumption affordably and sustainably, while sustaining (or enhancing) operational capability.

At Installations

The Department established an Executive Committee, led by the Deputy Under Secretary of Defense for Installations and Environment, to address the goals set forth in recent federal energy guidance, including the Energy Policy Act of 2005, Executive Order 13423: "Strengthening Federal Environmental, Energy, and Transportation Management" and the Energy Independence and Security Act of 2007. The Executive Committee is coordinating and prioritizing these initiatives and is serving as a conduit to the Energy Security Task Force for installation and environmental energy issues. The Department has a head start in achieving these goals, and a few examples outlined below. Additional examples and details can be found in the Annual Energy Management Report (http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy07/DoD-Narrative-Final.pdf).

Net-Zero Plus Initiative at the National Training Center (NTC), Fort Irwin, California. NTC is currently exploring the feasibility of removing their facilities completely from the electric grid (making them energy-secure) and could have the potential to sell "green" energy back to the California grid. The Army has named Fort Irwin as a Net-Zero Plus Installation and supports taking Fort Irwin off the electrical grid.

Efficient technologies for housing demonstration, Fort Belvoir, Virginia**.** The Power Surety Task Force and the Army's Rapid Equipping Force are demonstrating spray foam insulation and a solar power and storage system in Fort Belvoir housing in July 2008. The Fort Belvoir demonstration includes a "control" case (with no new energy technologies) and will test the effectiveness of several technologies in three additional houses, each with successively more energy technologies. This $115,000 demonstration will provide data enabling us to determine the most cost effective combination of insulation and solar cells. If successful, the insulation, at a minimum, could be retrofitted in many attics and office buildings on all military installations to achieve significant savings.

Fig. 3. Installing foam insulation on houses at Ft. Belvoir

Pentagon Wedge 5 Renovation**.** The Pentagon Renovations office has approved the use of LED light fixtures in place of the fluorescent and other lights used in the previous renovated wedges. The effort involves 4,200 light fixtures, each of which uses approximately 20W less energy, yielding a total energy savings of 376,000 kWh/year for all of the lights (i.e., for one-fifth of the Pentagon). The fixtures are expected to last about 11.5 years, resulting in a net savings of about $4 million over the life of the fixtures.

For Platforms

Fuel efficiency for turbine engines**.** The Highly Efficient Embedded Turbine Engine (HEETE) initiative, part of the Versatile Affordable Advanced Turbine Engine (VAATE) program, is developing high-pressure ratio, high temperature core technology, with the potential to reduce specific fuel consumption up to 25 percent over today's systems. HEETE is addressing the highest technical risk element in new engine development – the high pressure compressor component development. The current schedule includes a rig test in FY 2010, demonstrating a technology readiness level of four or five in a laboratory or relevant environment. These technologies are applicable to all turbine engines and could be used in commercial aircraft.

Efficient engines for Unmanned Aerial Vehicles (UAVs) and generators**.** The Small Heavy Fueled Engine demonstration is a three year program, initiated in FY 2008, and is anticipated to increase fuel efficiency and power density by 20 percent for UAVs and generators. The three engines assessed in the demonstration will operate on heavy fuels such as JP-8, thereby reducing the number of different fuels used on the battlefield and reducing the strain on the logistics tail.

Testing fuel efficient equipment on ground vehicles**.** The Fuel Efficient Demonstrator (FED) is testing the feasibility and affordability of achieving significant decreases in fuel consumption in a tactical vehicle, without sacrificing the performance or capability. This program is integrating potentially high-payoff fuel efficient technologies, like efficient propulsion and drivelines, and advanced lightweight materials in new and innovative designs. Successful technologies may be

incorporated in future procurements for the Joint Light Tactical Vehicle (JLTV). FED is employing a concurrent parallel strategy combining a traditional systems integrator approach with a "monster garage" approach. Both contracts were awarded in August 2008. This program will also benefit the science and engineering workforce by providing hands-on experience across a broad range of technical areas. High-potential government engineers from across DoD will work side-by-side with the contractor engineers in one year developmental assignments, building skills in vehicle design, systems engineering, vehicle integration, modeling and simulation, testing, and project management.

Fig. 4. Diesel hybrid vehicle testing at Hickam AFB

Diesel hybrid vehicle testing. The Department is testing various diesel hybrid vehicles. Hickam Air Force base is testing a plug-in parallel hybrid drive system to be integrated into a step van that will provide improved efficiency, superior performance and greater fuel economy. The system design consists of a 2.5 liter / 75 kilowatt diesel engine, a 97 kilowatt AC induction motor, and a continuous variable transmission. The Air Force is also testing and demonstrating Heavy Duty Hybrid Electric Class 8 Mack Trucks, with an Integrated Starter Alternator Motor which assists the diesel engine to provide power to the drive train. The trucks are being used by the Civil Engineering and Aircraft Refueling activities.

Extended range UAVs**.** The Air Force completed a preliminary design review for a prototype long endurance UAV to fly medium altitude missions un-refueled for five to seven days. The intent of this demonstration was to provide for affordable persistent surveillance using the latest energy efficient aviation technologies. Although the preliminary design review found the budget was insufficient to build and demonstrate a flying prototype, insights from this program may be integrated into other ongoing UAV programs, including the Army's Orion program.

To provide extended intelligence, surveillance and reconnaissance mission capability, the Naval Research Laboratory (NRL) is developing a fuel cell powered UAV with a projected endurance exceeding 24 hours operation on hydrogen gas. The UAV and fuel cell are being designed as an integrated package, and the project is planned for completion in 2009.

There are also two Joint Capability Technology Demonstration (JCTD) programs investigating even longer flight times. The Global Observer JCTD will demonstrate a liquid hydrogen powered unmanned aerial vehicle, using a modified, off-the-shelf internal combustion engine, capable of flying extremely long endurance, up to 7 days, with a moderately sized payload capacity at an altitude of 55-65,000 ft. The Zephyr JCTD will demonstrate and transition into service a solar-powered unmanned aerial vehicle capable of flying continuous operations for months at a time using solar power plus batteries for continual day/night operations.

Operational Efficiencies

We are working with the Combatant Commanders to understand their energy needs and concerns, which vary in priority among the different commands. For example, Central Command is primarily concerned with the dangers of inefficient fuel movement to forward operating bases, while the European Command is focused on the security aspects associated with energy suppliers using energy as a way to exert influence over other nations. The newly formed Africa Command is looking for sustainable energy capabilities for security cooperation to enable power generation or fuel generation in remote and/or austere environments.

The Power Surety Task Force (PSTF), formerly part of the Army's Rapid Equipping Force (REF), has been transferred to the ESTF, and one of their primary roles is to serve as a liaison with the Combatant Commanders and provide support for energy considerations. The PSTF currently has one person embedded full time at Multi-National Force Iraq. They also have tested a variety of new energy technologies that can be used in theater. Their process of first reducing demand, then conducting an engineering assessment to remove wasteful generation or excess capacity, and finally, supplementing with alternative and renewable energy has resulted in several quick wins, will enable forward bases and other installations to set the foundation for optimizing energy use in the long-term.

Technology demonstrations at forward operating bases**.** In an effort to demonstrate the operational efficacy of demand reduction coupled with alternative/renewable power, the PSTF and the National Training Center, at Fort Irwin, California, installed energy efficient structures (domes, Spray-Foam insulation, renewable power generator, efficient heating, ventilating, and air conditioning systems) in the training area. These structures show ground commanders how a holistic approach can provide an estimated energy savings of about 60 percent. This proof of concept effort was completed in just over 90 days and was the forerunner of the Net-Zero Plus Joint Concept Technology Demonstration (JCTD) sponsored by the U.S. Central Command to make forward operating bases energy independent for power generation.

Fig. 5. Monolithic dome and renewable energy generator at NTC

The JCTD will prototype, measure and assess a variety of technologies that would, collectively, use less energy than they create (using both demand reduction and renewable technologies) and determine which, if any, should be recommended for inclusion in sustainable design efforts in the DoD Installations community. As a result of these demonstrations, Fort Irwin leaders are considering the expansion of these technologies to their entire base. According

to their analysis, a $25 million investment has the potential to save $105 million in five years with a break-even point of nine months.

Fig. 6. Sprayfoamed tents at FOB in Afghanistan

In July 2007, the PSTF and REF demonstrated a technique for insulating temporary structures, such as tents and containerized living units, using an exterior application of spray foam. The resulting energy savings of 40 to 75 percent led Multi-National Force Iraq to award a $95 million contract to insulate nine million square feet of temporary structures. Based on extrapolated data from previous demonstrations, the additional nine million square feet of insulated temporary structures could save over 77, 000 gallons of fuel per day in theater, equivalent to about 13 truckloads of fuel, with associated cost savings of over $300,000 per day at $4 per gallon (not including the military logistics and force protection saved from the demand reduction).

Increased use of simulators for training. Preliminary studies have indicated that the increased use of simulators could potentially yield significant savings, resulting from reduced fuel costs, maintenance, and platform "wear & tear". The Joint Staff is leading a study to assess current simulator usage, develop a cost model for the business case supporting greater simulator use, and determine the feasibility of substituting additional simulator time for live training without decreasing operational capability. The Phase I assessment was completed in July 2008, and the potential energy savings could be very large. The final report is due in June 2009.

GOAL 2: Assure Supply

We need assured supplies of energy, to include having fuel and other energy sources available and able to get to where they are needed, to ensure mission sustainability. We are shifting reliance toward alternative and renewable sources of energy, thereby reducing our dependence on non-assured sources of oil.

Fig. 7. Disruption of oil supply

Renewable Energy

The Installations Community is serving as our model for renewable energy. In FY 2007, the Department reduced energy usage by over 10 percent from the 2003 baseline and almost 12 percent of our electricity was generated from renewable energy sources. While we are increasing our use of "traditional" renewable energy sources (solar, wind, etc.), we also are exploring new technologies, such as ocean and wave harvesting.

Solar power. Solar power is the largest contributor in the Air Force's renewable energy development program. In December 2007, the Air Force commissioned the largest photovoltaic solar array in the Americas (14.2 megawatts) at Nellis Air Force Base. This supports about one fourth of the base's energy usage per day and has an estimated annual cost savings of $1 million. In 2007, the Air Force continued to lead the federal government in green power purchases, with 37 bases meeting some portion of their base-wide electrical requirements from commercial sources of wind, solar, geothermal, or biomass. They are planning to add additional solar projects on underutilized land using the enhanced used lease authority and issued three requests for qualifications (RFQs) on January 29, 2008. The Air Force is currently reviewing the responses to the RFQs and identifying the next steps.

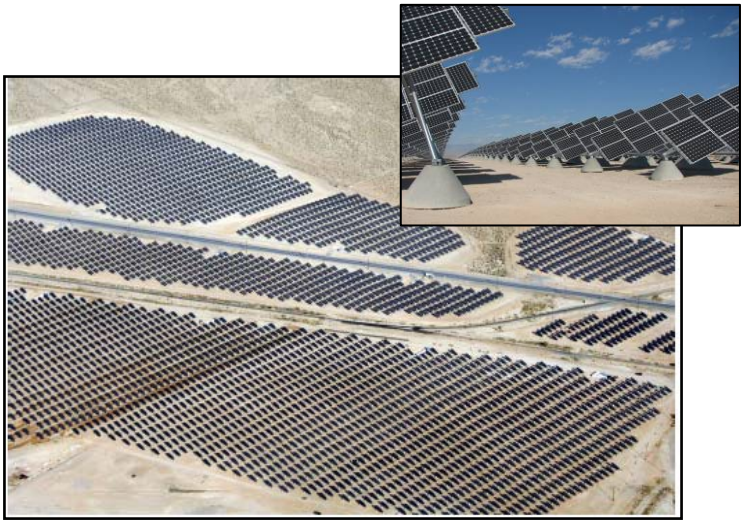

Fig. 8. Nellis Air Force Base solar array

Geothermal power. The Navy has made good use of the authority in 10 U.S.C. 2922a to receive revenues from geothermal power facilities, as they have done with the development of the 270 megawatt plant at China Lake, California in the 1980s that provides enough power to supply electricity to 180,000 homes. The Navy recently awarded a contract to build a 30+ megawatt geothermal plant at Fallon Naval Air Station, Nevada, and the Department is looking at other opportunities for similar public/private ventures. The Department is exploring the feasibility of expanding the title 10 authority to enable DoD to receive revenue from other energy resources on its lands. Ground source heat pumps are increasingly being used, particularly at housing units. For example, Offutt AFB has installed 1,131 tons of ground source heat pumps for its dorms.

Fig 9. Geothermal power plant at China Lake

Testing other potential energy generation technologies. The Navy is testing other energy sources for their feasibility to produce energy cost effectively. The Navy installed the first wave power buoy at Marine Corps Base Kaneohe Bay, Hawaii, and is partnering with industry to test a second buoy. In addition, the Navy is contracting with a commercial firm to provide a technology demonstration of tidal energy harvesting in the Puget Sound area. The Navy also is

partnering with the British Government to design and install a barge mounted off-shore Ocean Thermal Energy Conversion (OTEC) plant for electrical and water requirements at Diego Garcia.

Solar roofs. Thin-film solar panels are being used increasingly by the Department. Naval Base Ventura County installed an 87 kilowatt rooftop amorphous silicon thin-film photovoltaic (PV) laminate system on a building in Port Hueneme, California, and the Navy also installed photovoltaic parking garages at Naval Base Coronado, North Island, California, producing one megawatt of power. The Defense Commissary Agency initiated installation of a roof mounted, PV array capable of producing an estimated 152 kilowatts at the Los Angeles AFB Commissary in California. The project was funded through the Energy Conservation Improvement Program (ECIP) with construction to be completed in FY 2008.

Fig. 10. Photovoltaic parking garage at Naval Base Coronado, North Island, California

Alternative Fuels/Energy Sources

The Department is pursuing a variety of efforts in alternative fuels, primarily focused on testing and certification, enabling our systems to use different fuels regardless of the feedstock or production method. We already rely on local fuel sources in theater, like Jet A-1 (commercial jet fuel) in Europe, which differs slightly from JP-8. Efforts include improving the combustion process of engines using alternative fuels, optimizing fuel composition, understanding the equipment and systems impacts of alternative fuel use, such as corrosion and wear, and establishing protocols for alternative fuels qualification in aircraft, ships, vehicles and generators.

Synthetic fuel (synfuel) certification**.** Several efforts by the Services are underway to test and certify synfuels on both aircraft, ground vehicles, and support equipment. For example, in August 2007, the Air Force certified the B-52 to use a 50/50 blend of synthetic fuel and conventional aviation fuel. Tests are underway to certify the C-17, B-1, F-15 and F-22 in the near future, with an objective to certify the entire Air Force fleet by early 2011. In December 2007, a C-17 completed the first transcontinental flight using a synfuel blend, and in March 2008, a B-1 flew at supersonic speeds using a synfuel blend, demonstrating the applicability of synfuel for operational use. The Air Force has a goal to cost-effectively acquire 50 percent of its continental U.S. aviation fuel via a synthetic fuel blend utilizing domestic feedstocks and produced in the United States by 2016, with the intent to require that the synthetic fuel purchases be sourced from suppliers with manufacturing facilities that engage in carbon dioxide capture and effective reuse resulting in the use of fuels that

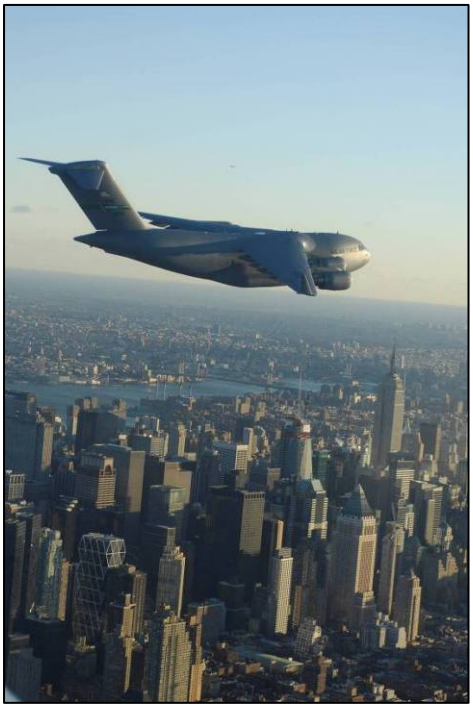

Fig. 11. C-17 transcontinental flight

have a "greener" life cycle environmental foot print the petroleum-derived products.

The Air Force is developing an Assured Aerospace Fuels Research Facility to support the study and evaluation of how processing and upgrading operations, conditions, and catalysts impacts the production, characteristics, quality, and carbon dioxide (CO_2) footprint of jet fuel made from alternative sources. Joint studies sponsored by the Air Force and the Department of Energy (DOE) show potential life cycle CO_2 reductions below that of conventional petroleum if waste biomass is combined with coal to produce aviation fuels via Fischer-Tropsch (FT) processing. This facility will enable the Air Force to conduct a comprehensive analysis of the potential that biomass may offer to reduce the life cycle CO_2 footprint of FT technology. Looking beyond FT fuels, the Air Force, in partnership with DARPA and industry, is investigating the suitability of second and third generation biomass-derived transportation fuels (e.g., cellulosic biomass, algae oils, animal fats, etc.) as renewable feedstock options for aviation use.

The Navy is conducting research on the effective use of alternative logistics fuels in naval power systems. These efforts include addressing the impacts these fuels have on engine internals and fuel distribution system components, optimizing fuel composition and improving the combustion process. The Navy also is establishing protocols for alternative fuel qualification for use on naval vessels and aircraft. In addition, the Army is testing a wide range of alternative fuels at the Army Research, Design, and Engineering Command in Warren, Michigan.

The Services and the Defense Energy Support Center are also working closely with the Commercial Aviation Alternative Fuels Initiative that represents the airlines, airports, and manufacturers to efficiently and economically certify the commercial airline fleet. This effort builds on the fact that many aircraft in the commercial and military fleets share common platforms, systems and engines.

Investment in biofuels**.** Commercially available biofuels are in limited supply and have lower energy density than their petroleum-based equivalent. Research suggests that some bio-based feedstocks could be converted into hydrocarbon fuels efficiently and affordably. Since the military's primary fuel source is jet fuel, DARPA is demonstrating the ability for oil rich crops, such as algae, cuphea and jatropha, to create JP-8 at energy density levels sufficient to power military systems. DARPA is soliciting research proposals for technologies that could enable the affordable production of jet fuel alternatives using agricultural or aquacultural crops that are non-competitive with food material (http://www.darpa.mil/baa/baa08-07.html).

Carbon capture and reuse**.** In FY 2007, the Air Force and the Office of the Secretary of Defense collaborated with the Department of Energy's National Energy Technology Laboratory (NETL) and Arizona Public Service in a program to develop a method to use algae to reuse CO_2. The work involves development of an algae-based CO_2 absorption system which produces algae oils that can be further developed into jet fuel. The Air Force helped develop the establishment of a laboratory at Arizona Public Service to study this algae oil-to-jet fuel process. Currently, the Air Force is preparing to conduct limited work with NETL in a joint FY 2008 program to look at options for carbon capture and reuse. The Air Force is also beginning to collaborate with DOE's Idaho National Laboratory to expand efforts involving CO_2 capture and reuse.

Biodiesel life extension program ("O28 O2Diesel"). Military vehicles can experience mechanical problems when using standard biodiesel, as stagnant biodiesel develops microbial growth leading to contamination and degradation. The Air Force is completing a $5 million demonstration with an ethanol/bio-diesel fuel blend (7 percent ethanol/20 percent pure biodiesel), with tests conducted on numerous vehicles in a variety of different climates. The new blend ("O28 O2Diesel") eliminates and prevents the contamination while reducing particulate matter emissions by up to 80 percent. In addition, the Navy is constructing a biodiesel production facility to further prove the feasibility of using cooking oil to produce fuel.

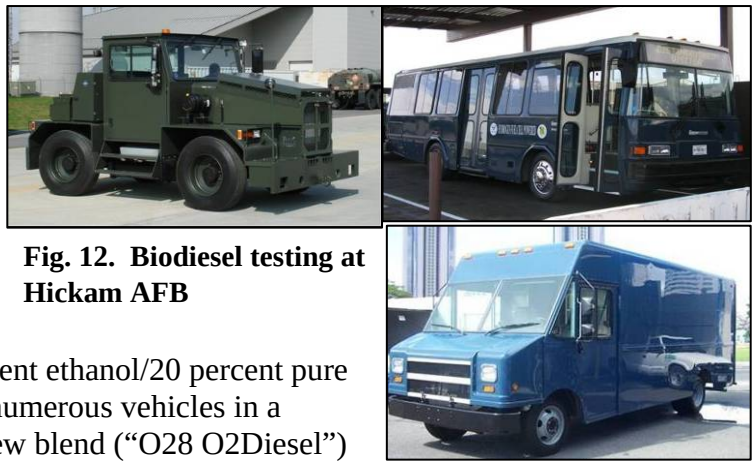

Fig. 12. Biodiesel testing at Hickam AFB

Hydrogen technology testing. The Air Force Advanced Power Technology Office (APTO) is conducting H_2 technology and capability demonstrations at Hickam AFB. Hickam's hydrogen vehicle fleet consists of various types of alternative powered vehicles. One is the Air Force's first fuel cell vehicle, a battery dominant hybrid system with a 20kW fuel cell power module. Another vehicle is a Hydrogen Powered Fuel Cell Dominant Step Van with 110/220v AC outlets. Two other vehicles used on the flight line are a hydrogen fuel cell bobtail Tow Tractor and a hydrogen powered fuel cell augmented flight line support vehicle that is having power conditioning integrated into the utility bed. Additionally, testing is being conducted using hydrogen refueling infrastructure. Commissioned in November 2006, the hydrogen refueling station supports both military and commercial vehicles, producing up to 50kg of hydrogen per day. The station consists of a fuel processor (electrolyzer), pressure management, and pressure storage. A new configuration will include solar panels to provide power to the refueling station. Similar hydrogen vehicle and infrastructure testing is slated to occur at Robins Air Force Base, beginning in late 2008.

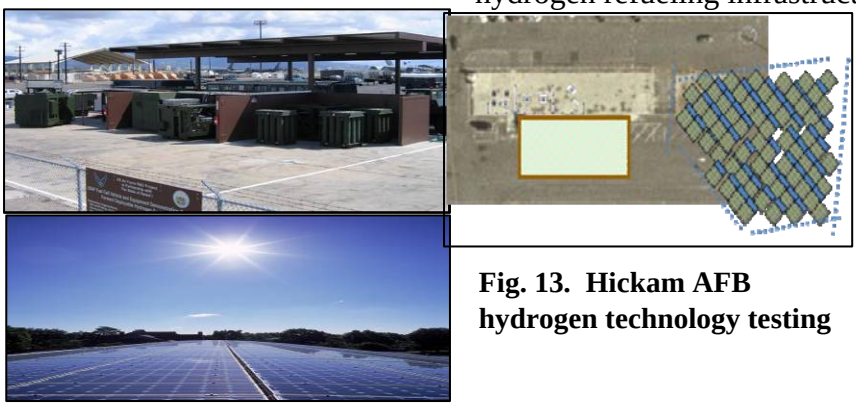

Fig. 13. Hickam AFB hydrogen technology testing

The Navy is continuing a hydrogen fuel station and non-tactical fuel cell vehicle (FCV) demonstration at Camp Pendleton Marine Corps Base, California. This effort is an Environmental Security Technology Certification Program (ESTCP) project to demonstrate and validate an on-site steam methane reformer for

Fig. 14. Naval fuel cell vehicles

hydrogen production. The project successfully completed demonstrations with a General Motors (GM) hydrogen fuel cell pick-up truck and sports utility vehicle in FYs 2006 and 2007, and will lease three GM FCVs to demonstrate extended vehicle range capability and to provide fuel cell test data in support of potential naval electric ship applications.

Waste-to–energy systems**.** The Air Force APTO is working to integrate a waste-to-energy system at Eielson Air Force Base, Alaska. This system will be an advanced gasification-based core technology with the capacity to convert 10 to 50 tons per day of a wide variety of waste materials into 1 megawatt of clean electricity, to be used onsite by the base, thereby reducing the amount of electricity purchased from the local grid. This will reduce energy costs and improve the security of the base, enabling the base to use onsite sources to produce renewable energy, independent of the local grid. In a rapid-deployment scenario, the technology can help the Air Force reduce the use of imported fuels at installations in the short term. Waste-to-energy systems provide a tool for achieving both the renewable energy and landfill avoidance goals established by Executive Order 13423.

Fig. 15. Waste to energy technologies, Eielson, AFB

Very high efficiency solar cells**.** DARPA demonstrated breakthrough conversion efficiency with a set of solar cells – over 42 percent – and is currently using this set in a proof-of-concept solar power module with an objective of 40 percent efficiency, which would be almost double that of current solar power modules. The end-of-program goal is to achieve 50 percent efficiency affordably at the module level. The DARPA module is using a novel lateral cell design that will be optimized in spectrally split band gaps (high, medium-high and low). If successful, this could be a game changer, making solar energy cost effective.

Nuclear Energy Initiative**.** The Air Force was asked by several members of the U.S. Senate to determine if Air Force bases could be appropriate siting locations for small package nuclear power generation facilities. In January 2008, the Air Force issued a request for information (RFI) to gauge industry's interest in the concept, and to solicit their ideas on potential technologies, financing options, and other aspects of a potential project. In July 2008, the Air Force intends to follow the RFI with a request for qualifications for industry teams to pursue development of concepts for nuclear power projects that could be hosted on an Air Force base, and plans to begin to evaluate them beginning in August 2008. Pending the results of that evaluation, the Air Force will make a decision as to which proposal(s) it will pursue by October 2008. The Air Force model is for this completely commercially driven. The Air Force will not build, own, operate, or license a nuclear power plant. The goal is to provide a suitable site, and as a customer and market leader, provide the opportunity for the private sector to build and operate the plant, using an enhanced use lease (EUL), or similar, authority.

Tactical Power Systems and Generators

Transportable Hybrid Electric Power Stations (THEPS). The REF completed testing of Transportable Hybrid Electric Power Stations. These devices were requested by Major General Zilmer, Operational Commander in the Al-Anbar province in Iraq, in response to the vulnerability of U.S. Forces while delivering fuel. Although significant fuel savings were found, the systems were not robust enough for a forward operating base environment. However, insights from this effort were used to advance the Hybrid Intelligent Power program.

Hybrid Intelligent Power (HI-Power) generator**.** The HI-Power program is a revolutionary effort that will develop and validate a DoD standard tactical intelligent power management architecture that incorporates source management (including the use of renewable energy sources where applicable), energy storage technologies, power distribution, and demand management.

Fig. 16. Hi-Power generator at Ft. Belvoir, VA

Solutions currently being pursued include the development of active distribution networks and intelligent / automated hybrid power systems. Power management and distribution techniques will enable maximum power utilization with a high degree of efficiency for use with various mobile and portable applications in the 2 to 500 kilowatt range.

This power management architecture will include small and medium sized tactical versions for mobile forces and larger transportable systems appropriate for forward operating bases. Initial models estimate fuel savings of up to 40 percent compared to current systems, reduced maintenance and personnel requirements, and fewer power interruptions. The resulting architecture will impose minimum impacts on transportability, deployability, and readiness levels of current and upcoming platforms.

DoD hosted an Industry Day for HI-Power and released a Broad Area Announcement in July 2007. Three Small Business Innovative Research contracts were awarded in December 2007, and multiple awards from a December Request for Proposals were made in May 2008.

Tactical Garbage to Energy Refinery (TGER)**.** The REF has deployed two TGERs to Iraq for a capability demonstration and evaluation.

Fig. 17. Tactical Garbage to Energy Refinery (TGER)

TGER converts field waste (paper, plastic, cardboard and food slop) into biofuel that is used to power a 60 kilowatt generator. A battalion sized forward operating base (600-800 soldiers) creates about one ton of garbage per day that can be recycled into energy, so the system is designed to convert one ton of waste into energy equal to about 100 gallons of JP-8. It is skid mounted and deployable on a military 5-ton flatbed trailer. The units were deployed in May 2008 and are undergoing a 90 day evaluation in theater. The demonstration is off to a good start and will assist in validating the concept. Post-deployment, a transition decision will be made regarding further development.

Solid Oxide Fuel Cells. The Navy and Army are developing and demonstrating compact and mobile 10 kilowatt high temperature fuel cells to power critical equipment, including GPS, radio and communications equipment, computers, intelligence, surveillance and reconnaissance gear, and laser designators. These systems provide silent, portable power and eliminate dependence on large generator or grid power for battery charging. These fuel cells are demonstrating a high efficiency (about 55 percent) and are being designed to be compatible with kerosene-based jet fuels such as JP-5 and JP-8. They provide low weight for the available energy content to the warfighter carrying them. Additionally, they will provide auxiliary power for applications on vehicles for missions over 24 hours.

Remote Site Tactical Hybrid Power. A former Brigade Commander in Iraq, Colonel Dave Bishop 3rd Brigade, 1st Armored Division, used excess electricity generated from his Forward Operating Base (Camp Taji) to provide power to the local Iraqi population as part of his engagement strategy to facilitate better community relations. This resulted in enhanced security for local population, enhanced security for coalition forces and created a safe and secure environment through a more cooperative relationship with the local population.

Expanding on this success, the REF has selected a vendor to deploy a hybrid generator (wind, solar, battery storage, back-up diesel) for US Forces at a Kuwaiti border crossing communications site, based on an assessment by the Power Surety Task Force. The intent of this effort is to demonstrate the efficacy of commercial hybrid power stations in meeting military needs in isolated, but fixed locations. A 90 day evaluation period will precede the final disposition decision.

GOAL 3: Improve Processes

The Department has made progress to incorporate energy considerations in its planning and business processes.

Requirements Generation and Acquisition

Energy in the requirements development process**.** In August 2006, the Vice Chairman of the Joint Chiefs of Staff signed a memorandum establishing the requirement for an energy-related Key Performance Parameter (KPP) for new acquisition programs to be selectively applied. KPPs are attributes or characteristics of a system that are considered critical or essential to the development of an effective military capability. The methodology and procedures for establishing program-relevant energy KPPs are under development. In May 2007, the Joint Staff

updated their directives[2] to require use of KPPs as established in the Vice Chairman's memo. The energy efficiency KPP requires life-cycle cost analysis to include the burdened cost of fuel in the Analysis of Alternatives (AoA) and/or Evaluation of Alternatives (EoA) and subsequent analyses and acquisition program design trades. In such analyses, the fully burdened cost of fuel is defined as the price of the fuel, plus its delivery chain and force protection requirements, all taken from a range of the applicable defense planning scenarios. This scenario-based force planning methodology will underpin both the KPP within the DoD requirements process (Joint Capabilities Integration and Development Process (JCIDS)) and the calculation of the fully burdened cost of fuel in acquisition.

Energy in the acquisition process. The acquisition process is currently under revision to more accurately value energy. In April 2007, the Under Secretary of Defense (Acquisition, Technology and Logistics) signed a policy memorandum to use the fully burdened cost of fuel (FBCF) as a major basis for all trade analyses for acquisition programs. The memo also established three pilot programs – the Joint Light Tactical Vehicle (JLTV), alternative ship propulsion for the next generation cruiser (CG(X)) and the Next Generation Long Range Strike (Next Generation Bomber) – to validate the approach and to facilitate development of policies and procedures for how to apply it in the acquisition process. The Under Secretary also directed the use of FBCF in ownership costs in a memo on implementing a life cycle management framework in July 2008. We expect to have guidance for the relevant acquisition procedures in place by October 2008 and will use the insights to develop procedures for establishing energy as a KPP.

Fuel logistics considerations in wargames**.** The Services have begun to incorporate additional energy considerations in periodic force planning wargames. These exercises will provide a better understanding of the impact of energy on operations in the mid- to long-term and will help the requirements and acquisition communities to evaluate the operational value of raising energy efficiency requirements of new systems and for refurbishment of legacy systems.

Partnering

The Department is actively seeking opportunities to partner with other federal agencies, industry, academia and the international community to leverage their ongoing efforts in energy. Through the monthly "Energy Conversations" sponsored by the ESTF, DoD is reaching out to other federal agencies and the community to educate and share information on energy. Additionally, a number of DoD components are working with the Combatant Commanders and the Power Surety Task Force to assess and resolve their energy needs. In addition to the Navy's partnership with the British on an OTEC plant at Diego Garcia, we are in discussions with UK, Australia and Canada to identify areas of commonality where we can cooperate. The Air Force continues its collaboration with the French Air Force and Royal Air Force (UK), focusing on alternative aviation fuels, energy conservation and environmental sustainability.

[2] Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3170.01F - Joint Capabilities Integration and Development System (JCIDS) and Chairman of the Joint Chiefs of Staff Manual (CJCSM) 3170.01C Operation of the Joint Capabilities Integration and Development System (JCIDS).

We are partnering with the Department of Energy, through the National Renewable Energy Lab, to develop a Net Zero Energy Installation process, which can be used by any installation to develop a plan for achieving its maximum potential energy efficiency and renewable resources. This partnership is currently working with Marine Corps Air Station Miramar, California, on a plan for that installation. The process at Miramar will be mapped and prototyped at a future location to work out contingencies. It will then be made available for other installations to develop location specific plans.

A small portion of Energy Conservation Improvement Program (ECIP) funding is being used to leverage ESTCP funding on facilities energy technologies. In FY 2007, these programs combined to fund four projects: a building integrated photovoltaic roof, innovative fast pyrolysis technology, liquid-desiccant outdoor air conditioning, and a micro-turbine power generator. In each of these projects, ECIP funds the construction, and ESTCP funds the monitoring and validation. Technologies that are proven through this process can then be spread throughout the Department.

GOAL 4: Establish Metrics

The Installations and Environment Community has a well-defined series of metrics to monitor energy consumption and the use of alternatives, as outlined in annual reports and scorecards. Examples are included in Appendix A. We are in the initial stages of considering how to adapt this for platforms, thereby enabling us to establish targets and evaluate progress.

SUMMARY

The Department has a balanced portfolio of energy efforts in place, either in testing or in the planning stages. Our business and planning processes are being amended to better determine the value of how and how much to reduce our energy-related risks, while maintaining or improving our capabilities. We are developing and testing technologies to manage supply and demand more effectively. The DoD Energy Security Strategic Plan will provide senior leaders with a clear, forward-leaning, and operationally-focused set of options to deliver a much more sustainable, resilient force with greater endurance over the full range of future missions. Our strategy recognizes the value of energy and puts us on a path to greater energy security.

Appendix A
Energy Goals

- Reduce fuel demand ➔ implies annual reduction [National Defense Strategy June 2008]
- Reduce installations energy usage by 30% by 2015 [EO 13423 / 2007 Energy Act]
- Reduce petroleum consumption for non-tactical vehicles by 20% by FY15 [2007 Energy Act]
- Certify synfuel in all Air Force aircraft by 2011 [Secretary of the Air Force goal]
- 25% of electricity from renewable sources by 2025 [NDAA 2007]
- Reduce fossil fuels in new/renovated buildings: 55% by 2010; 100% by 2030 [2007 Energy Act]
- 30% of hot water in new/renovated buildings from solar by 2015 [2007 Energy Act]
- Increase non-petroleum fuel by 10% per year [EO 13423/2007 Energy Act]
- Energy as selective Key Performance Parameter [CJCSI 3170.01F/CJCSM 3170.01C]
- Fully burdened cost of energy in tradeoff analyses [USD(AT&L) memo of April 07]
- Energy included in life cycle sustainment metrics for MDAPs [USD(AT&L) memo of July 08]
- Building metering data entered into benchmarking database [2007 Energy Act]
- Electricity metering by October 2012 [2005 Energy Act]
- Natural gas and steam metering by October 2016 [2007 Energy Act]